S-5/PHSH/CC-11/23

TDP (Honours) 5th Semester Exam., 2023

PHYSICS

(Honours)

ELEVENTH PAPER : CC – 11

Full Marks : 60 *Time* : 3 Hours

Answer from ***both*** *the Sections as directed.*

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

SECTION—A

1. Answer *any* **six** of the following questions : 2×6=12

(a) What do you mean by probability current density?

(b) Define commuting and non-commuting operators.

(c) What does a Gaussian wave packet represent?

(d) When is a particle said to be in bound state?

(e) What do you mean by excitation potential?

(f) Explain the existence of zero point energy.

(g) What is Stark effect?

(h) What do you mean by symmetric and anti-symmetric wave functions?

SECTION—B

There are *four* questions from Question No. 2 to Question No. 5. Answer either *(a)* **or** *(b)* from each question given below : 12×4=48

2. *(a)* (i) State Ehrenfest theorem and prove that

$$\frac{d}{dt}\langle x\rangle = \frac{\langle P_x\rangle}{m} \text{ and } \frac{d}{dt}\langle P\rangle = -\left[\frac{dv}{dx}\right].$$

(ii) Explain the orthogonality of energy eigenfunctions.

(iii) Write the expression for expectation value of position and momentum in terms of corresponding operators.

(1+2½+2½)+3+3=12

[Continued]

(OR)

(b) (i) State the postulates of quantum mechanics.

(ii) What is the physical significance of operator? Hence find the values of $(xp_x - p_x x)$ and $(yp_x - p_x y)$.

(iii) State the Heisenberg's uncertainty principle. Consider an electron of energy 200 eV is passed through a circular hole of radius 10^{-4} cm. Find the uncertainty introduced in the angle of emergence. 2+(2+3)+2+3=12

3. *(a)* (i) Solve Schrödinger's equation for a particle in a square well potential defined by

$$V(x) = \begin{cases} 0 & , \ 0 < -a \\ -V_0 & , \ -a < x < a \\ 0 & , \ a > x \end{cases}$$

(ii) Explain about the symmetric and anti-symmetric wave functions in the above case with graphical representation.

[Turn Over]

(iii) Also find out the energy eigenvalue for the corresponding symmetric and anti-symmetric wave functions. 4+4+4=12

(OR)

(b) (i) Obtain an expression for the energy eigenvalues of the harmonic oscillator applying Schrödinger's equation and plot the energy levels of the oscillators.

(ii) Write the 1st three normalised wave functions of the harmonic oscillator and show them graphically.

(iii) The radial part of wave function for hydrogen atom in the ground state is given by

$$R = \frac{2}{a_0^{\frac{3}{2}}} e^{-\frac{r}{a_0}}$$

Find ground state energy of hydrogen atom $(n = 1, l = 0)$. 4+4+4=12

4. (a) (i) Draw and explain the continuous and characteristics X-ray spectra.

(ii) State and explain Mosley's law on the basis of Bohr's theory.

(iii) Find the value of total angular momentum $\vec{J}$ for one electron atom in case of $l = 1$. (1+4)+(1+3)+3=12

(OR)

(b) (i) Explain various quantum numbers associated with vector atom model.

(ii) Describe the general theory of anomalous Zeeman effect with special reference to D_1 and D_2 lines of sodium.

(iii) Calculate the energy of k_α-line of copper $(Z = 29)$; given $R_H = 1{\cdot}097 \times 10^7/\text{m}$. 4+5+3=12

5. (a) (i) Explain L-S coupling and J-J coupling with the help of vector diagram. Mention selection rules for L, S and J.

(ii) Calculate the spectral terms for non-equivalent (S,S), (S,P) electrons.

(iii) Find out Lande's g factor and total magnetic moment for $2P_{\frac{3}{2}}$ state. (3+2)+4+3=12

(OR)

(b) (i) Explain the origin of stokes and anti-stokes lines in Raman spectrum. Mention selection rules in the above two cases.

(ii) Write two important applications of Raman effect explaining how it is used to study molecular structure.

(iii) Explain about vibrational-rotational spectra of diatomic molecules with energy level diagrams.

(2+2+1)+3+4=12

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